XLII.—*The Taxonomy of Recent Species of* Limulus.

By R. I. Pocock.

[Plates V. & VI.]

Part I.—The Question of Names.

The existing species of *Limulus* are restricted in range to the eastern coasts of North and Central America and the shores of the Malayan and Chinese seas. Anyone acquainted with problems of geographical distribution would expect to find structural differences of more than specific value between the species inhabiting areas so long and widely sundered. An examination of all available material has justified this expectation to the full. It has shown that the American form is distinguishable from the Oriental by many points certainly worthy at least of generic recognition; also that the three known species from the Indian seas, while agreeing with one another in the main, are at the same time divisible into two well-marked groups, one of which is typified by *L. rotundicauda*, the other by the two species which currently pass as *L. moluccanus* and *L. longispina*. These two types I have regarded as valid genera, keeping for the latter the name *Tachypleus* of Leach, and proposing for the former the new name *Carcinoscorpius*. Furthermore, I have linked these two genera together to form the subfamily Tachypleinæ, reserving the name Xiphosurinæ for the American genus.

This division of the old genus into three genera demands a settlement of the question as to which of them should bear the name *Xiphosura*, of which *polyphemus* of Linnæus is the type.

Under the name *Monoculus polyphemus*, Linnæus (Syst. Nat. ed. x. p. 634, 1758) confounded two species, namely the American and the Moluccan, as can be seen from the references he cites. He may, however, be considered to have himself limited the name to the American species when, in 1764, he definitely described a specimen of that species as *polyphemus* (Mus. Ludovic. Ulr. p. 460).

This, perhaps, was the line taken up by Latreille in 1802, when, by restricting the name *polyphemus* to the American form, he reversed the action of Lamarck and probably also of Fabricius.

For the species characterized as *Monoculus polyphemus* in the tenth edition of the 'Systema,' Gronovius (Zoophylac. &c., Ins. p. 220, 1764) proposed the name *Xiphosura*, giving an

admirable and unmistakable diagnosis of the genus and citing *polyphemus* as a representative of it, though by reference and number, not actually by name*.

Müller, like Linnæus, mixed up the Moluccan and American species under the name *Limulus gigas* (Entomostr. p. 126, 1785). Following him came Fabricius (Ent. Syst. ii. p. 487, 1793), who restricted the name *Limulus* to the genus typified by *gigas*, or, as he called it, *polyphemus*, and thus anticipated by eight years Lamarck's proposal to call the same genus *Polyphemus* (Syst. Anim. sans Vert. i. p. 168, 1801). Rightly, I think, have these genera been regarded by common consent as synonyms; and whether we call the genus *Xiphosura* or *Limulus*, its type is *polyphemus* as limited in the catalogue of the Mus. Ludov. Ulr. 1764. The only other genus introduced into this family is *Tachypleus*, founded by Leach upon a character peculiar to the male sex and noticed by him in a specimen of one of the eastern species. There is no reason to doubt that this species is the one that Latreille described as *heterodactylus* and *moluccanus*; and since Leach cites *heterodactylus* as belonging to his genus *Tachypleus*, we may take that species as its type.

Although *Tachypleus* was constituted on insufficient data, the name must be reserved for the group of king-crabs containing *gigas* (=*moluccanus*) and *tridentatus* (=*longispina*), to which I have here given generic rank.

Into the specific nomenclature only two changes have to be introduced: this is the restoration of the name *gigas* for the Moluccan species and the substitution of *tridentatus* for *longispina* in the case of the Chinese species.

Part II.—Material.

The material worked upon is that preserved in the British Museum. Although the collection contains the young and adults of both sexes of all the usually recognized species, it is scanty enough. Considering the quantities of specimens of

* Latreille admitted the claims of *Xiphosura* to generic recognition and deprecated the action of Müller and Fabricius in renaming the same genus *Limulus*. In his unwillingness to side altogether with these authors in ignoring the work of Gronovius, he effected a compromise, retaining *Limulus* for the genus and erecting *Xiphosura* to ordinal rank. It appears to me, however, that Gronovius's name should be recognized for the genus, although he cites no species by its technical name as the type. His genera rest on exactly the same basis and have the same right to recognition as Brisson's genera of mammals (see on this point Jeffrey Bell's vindication of Gronovius in Ann. & Mag. Nat. Hist. (6) xix. p. 239, 1897). I cannot find in the work of Gronovius any reference to "*Xiphotheca*, Gronovii," quoted by Leach in Dict. Sc. Nat. xiv. p. 536 (1819).

the American form that have been received, dead and alive, in England within the last twenty years, we are very badly off for examples of this species. Any specimens that anatomical lecturers have to spare would make a welcome addition to the national series. So, too, with the Oriental species. There is probably a great deal yet to be learnt about them; yet specimens are usually considered not worth the bringing, or not worth the keeping if brought. Especially is it to be regretted that none of the 'Challenger' material has found its way into the British Museum. Presumably it was dispersed for anatomical purposes, and discarded as useless when done with.

Part III.—Generic and Specific Characters.

Most of the characters here used as a basis for classification are manifest enough. Some have been employed before, but with only a specific valuation, and many of the most obvious are figured in Van der Hoeven's classic monograph, though, oddly enough, they are completely ignored in the text. In the specific diagnoses, for example, while great stress is laid upon the relative prominence of the posterior angular prolongation of the opisthosoma, the serration and shape of the postanal spine, the form and number of claspers in the male, yet the structure of the genital operculum and the radical differences that obtain between this appendage in the American and the Oriental species, the absence of the spur on the sixth leg in *rotundicauda*, the absence of the spike on the sides of the gill-chamber in *polyphemus*, the difference in position of the anterior spike of the lateral series on the opisthosoma in the two sets of species—all of which the artist has faithfully portrayed—are passed over unnoticed in the letterpress. The same omissions are observable in the work of H. Milne-Edwards in 1840 (Hist. Nat. Crust. iii. pp. 547–550). These authors, in fact, like their predecessors, evince only superficial acquaintance with the external structural features of *Limulus* or an inappreciation of their value. Subsequent writers have for the most part paid attention to the more important questions relating to the affinities of this animal with other Arthropoda, setting aside as uninteresting or well known the affinities of its species to one another.

The organ which supplies the basis for the classification given below is the genital operculum. As was long ago pointed out in Claus's 'Lehrbuch,' this appendage differs

constantly in the American and Oriental species *. On the supposition that the operculum was originally similar to the appendages that follow it, there can be no question that the American species possesses a more primitive type of this appendage than the Oriental. In the former the endopodite ends in a free movable segment, representing the two distal segments of this branch seen in the branchial appendages. In the Oriental species, on the other hand, the three segments of the endopodite of the branchial appendages are represented in the operculum by a triangular segment fused externally to the exopodite and mesially to its fellow of the opposite side †.

In the branchial appendages of the opisthosoma the wart-like sensory organs on the endopodite are fairly constant in number and position in all the species. Typically there are five, placed as shown in Pl. VI. fig. 6, but the smaller of the two on the distal segment is sometimes, perhaps generally, wanting in *rotundicauda*.

I find one slight difference in the endopodites between the American and Oriental species. This is the presence in the former of a small movable spine on the inner distal angle of the penultimate segment (Pl. VI. fig. 7). This spine is absent in the Oriental species.

In the development of secondary sexual characters the American species is again less specialized than the Oriental. In the former only the second appendage of the prosoma is modified as a clasper and there is no variation in the spines of the opisthosoma in the female. In the Oriental, on the other hand, the second and third pairs of appendages of the prosoma are converted into holders in the male and the three posterior spines of the opisthosoma in the female are markedly shorter than the anterior, especially in *Tachypleus*. *Carcinoscorpius*, in this respect, is less specialized, as also it is in the chelate condition of the claspers, a peculiarity which clearly preceded the hemichelate condition of these appendages observable in *Xiphosura* and *Tachypleus*.

* Owing to an error in specific determination, Dr. H. Woodward (Pal. Soc., Merostomata, pt. iii. p. 115, 1872) regarded these differences as referable to sex, assigning the operculum of *L. rotundicauda* or *L. moluccanus* to the male of *L. polyphemus*, and the operculum characteristic of both sexes of *L. polyphemus* to the female of that species. Latreille was apparently the first to set this error rolling.

† Except in the species identified by Hoeven as *L. moluccanus* (see p. 264), where the two appear to remain unfused in the middle line.

Part IV.—Classification of King-Crabs.

Order XIPHOSURÆ.

Family Xiphosuridæ.

Subfamily *Xiphosurinæ* (= *Limulinæ*), nov.
(Pl. V. fig. A and Pl. VI. fig. 7.)

Genital operculum with the distal or third segment of the inner branch retained as a freely movable sclerite, distinct both from the second segment, to which it is jointed, and from the distal segments of the outer branch of this appendage, which is widely separated from its fellow of the opposite side in the middle line.

Entosternum with two pairs of long antero-lateral processes.

Second pair of prosomatic appendages modified as *claspers* in the male.

Opisthosoma more vaulted, not so markedly hexagonal, owing to the lesser prominence of the lateral angle, which lies well in advance of the middle of the lateral border, making the spiniferous edge much longer than the part of the border that has no movable spines; the latter abruptly bent downwards in the posterior two thirds of its length, the spike that it bears lying in front of its middle and much nearer to the "waist" than to the spike preceding the first movable spine; posterior prolongation of opisthosoma more prominent, the inner edge straight and cutting the outer at an acute angle. Lateral crest bordering the gill-chamber on the lower side of the opisthosoma without a strong spike, but posteriorly evenly continuous with a serrated ridge which borders the gill-chamber behind.

Lateral movable spines of opisthosoma alike in both sexes, becoming progressively shorter from before backwards, and gradually tapering from base to apex.

Sixth prosomatic appendage with its fifth segment thick, subcylindrical, not longer than the sixth.

Penultimate segment of endopodite of *branchial appendages* of opisthosoma armed apically on the inner side with a movable spine.

Distribution. Eastern coast of North and Central America.

Genus Xiphosura, Gronovius (= *Limulus*, Müll., as restricted by Fabricius).

Apart from the features mentioned above under the heading Xiphosurinæ, some of which should perhaps be considered rather of generic value, this genus presents the following characters:—

Sixth prosomatic appendage with movable spur at the distal end of the underside of the fourth segment. Postanal spine triangular in section, carinate above, lightly convex or flattish, not excavated below. Clasper of male hemichelate, the immovable digit reduced to a short, thick, thumb-like prominence.

Xiphosura polyphemus (Linn.).

Monoculus polyphemus, Linn. Syst. Nat. ed. x. p. 634 (1758) (in part.); id. Mus. Ulr. Reg. p. 460 (1764) (sensu stricto).
Limulus gigas, Müller, Entomostraca, p. 126 (1785) (in part.).
Limulus cyclops, Fabr. Ent. Syst. ii. p. 488 (1793) (by tradition).
Limulus occidentalis, Lamarck, Syst. Anim. sans Vert. p. 168 (1801) (nomen nudum); id. ed. 2, vol. v. p. 147 (1818).
Limulus albus, Bosc, Hist. Nat. Crust. ii. p. 237 (1802) (according to Desmarest).
Limulus polyphemus, Latreille, Desmarest, Leach, Van der Hoeven, Milne-Edwards, and subsequent authors.
Limulus Sowerbii, Leach, Zool. Misc. ii. p. 84.
Limulus americanus, Leach, Dict. Sci. Nat. p. 537 (1819).

Distribution. This king-crab is said to range from the coast of Maine to Yucatan in the Gulf of Mexico. Hardly likely is it that more than one species is involved; but considering the different conditions of water-temperature to which the species must be subjected, it is probable that some interesting results would follow a comparison of a series of specimens from Cape Cod with a series from Yucatan.

Subfamily *Tachypleinæ*, nov.
(Pl. V. figs. B, C, D, and Pl. VI. fig. 6.)

Genital operculum more specialized than in *Xiphosura*, the terminal segment of the inner branch, which is retained by that genus, suppressed, probably by fusion with the second segment, the two being represented by a triangular plate, broad at its proximal, narrow at its distal end, movably jointed to its fellow of the opposite side internally, and to the terminal segment of the outer branch externally, by a sutural union. Thus the distal segments of the outer branches are terminally approximated in the middle line and not separated by a pair of movable segments.

Entosternum with a single pair of antero-lateral processes.

Second and third pairs of prosomatic appendages modified as *claspers* in the male.

Opisthosoma less vaulted, more markedly hexagonal owing to the greater prominence of the lateral angle which lies near the middle of the lateral border, making its spiniferous and non-spiniferous parts subequal; the latter not abruptly bent downwards posteriorly, the area behind its spike, which lies,

if anything, further from the waist than from the lateral angle, subparallel to the area in front of it; posterior prolongations of opisthosoma less prominent, their inner edge convex and cutting the outer at a right angle in the adult. Lateral crest bordering the gill-chamber on the lower side of the opisthosoma armed with a strong spike; no transverse serrated crest bordering the gill-chamber behind.

Lateral movable spines on opisthosoma in female short, abruptly narrowed and pointed at apex, not evenly tapering to a point.

Sixth prosomatic appendage with its fifth segment flat behind, strongly compressed and much longer than the sixth segment.

No spine on inner edge of penultimate segments of endopodites of *branchial appendages* of opisthosoma.

Distribution. Oriental seas from the Bay of Bengal to the coasts of China, Japan, the Moluccas, and Torres Strait.

Genus Tachypleus, Leach, emend.
(Pl. V. figs. C, D, E, and Pl. VI. figs. 1, 2, 4.)

Tachypleus, Leach, Dict. des Sci. Nat. xiv. p. 538 (1819); Desmarest, Consid. Gén. Crust. p. 356; Desmarest in Bosc, Man. Crust. ii. p. 198 (1830).

A movable spur present at apex of fourth segment of sixth prosomatic appendage. Inner branches of genital operculum not extending so far as tips of distal segments of the outer branch. Postanal spine triangular in section, crested above, hollowed below. Claspers of male hemichelate; the immovable finger stumpy and abbreviated, the movable thick in the middle, slender and cylindrical distally. Movable spines on lateral border of opisthosoma very dissimilar in the two sexes, of equal length and very long in the male and young female, the posterior three short and apically acute in the adult female.

Tachypleus gigas (Müller).

? *Limulus polyphemus*, Fabr. Ent. Syst. ii. p. 488 (1793) (nec *polyphemus*, Linn., 1764).
Limulus gigas, Müller, Entomostraca, p. 126 (1785) (in part.).
Polyphemus gigas, Lamarck, Syst. Anim. sans Vert. ed. 1, p. 168 (1801).
Limulus heterodactylus, Latreille, Hist. Nat. Crust. et Ins. iv. p. 89 (1802); id. Sonnini's Buffon, Ins. iv. p. 89 (1802); id. Gen. Crust. et Ins. i. p. 12 (1806).
Limulus moluccanus, Latreille, Hist. Nat. Crust. et Ins. iv. p. 92 (1802); id. Sonnini's Buffon, Ins. iv. p. 92 (1802); id. Gen. Crust. et Ins. i. p. 11 (1806); Van der Hoeven, Milne-Edwards, &c.
Limulus Latreillii, Leach, Dict. des Sci. Nat. xiv. p. 527 (1819).
Tachypleus heterodactylus, Desmarest, Consid. gén. Crust. p. 356 (1825).

This species is commonly known as *moluccanus*, Latreille, but the name *heterodactylus*, proposed by the same author, stands first in his earliest work and has the priority. It appears to me, however, that *gigas* of Müller as restricted by Lamarck will have to be adopted. Müller confused two species under *Limulus gigas*, namely, the American and the Moluccan. Lamarck, following him, restricted the name *gigas* to the Moluccan species, which he believed to be the *polyphemus* of Linnæus, naming the American species *occidentalis* (see Syst. Anim. sans Vert. i. p. 168, 1801; also v. p. 147, 1818).

From the description of *L. Latreillii* it appears that the type Leach had before him had but one spine upon the anal emargination above and a groove along the lower side of the postanal spine. These features coexist only in the species known as *moluccanus*.

Limulus virescens, Latreille (Gen. Crust. et Ins. i. p. 12, 1806), is, according to Milne-Edwards (Hist. Nat. Crust. iii. p. 548, 1840), exceedingly like *L. moluccanus*, but the type has *seven* rounded conical and pointed sclerites at the base of the penultimate segment of the sixth prosomatic appendage instead of the four of the normal flattened form. This feature is probably a case of abnormal development or of regrowth, a supposition borne out by the further statement that the penultimate segment of the leg in question is extremely short. Should the character prove to be normal and of constant occurrence, it must be regarded as the basis for a new genus.

Distribution. T. gigas has a wide range. The British Museum has specimens from Malaysia; Singapore (*Ridley*, *Bedford*, *Lanchester*); Gulf of Siam (*S. S. Flower*); Sarawak (*C. Hose*); Kudat (*S. S. Flower*); and Torres Straits (*J. B. Jukes*).

Tachypleus tridentatus, Leach.
(Pl. V. fig. E and Pl. VI. fig. 2.)

Limulus tridentatus, Leach, Dict. Sci. Nat. xiv. p. 537 (1819).
Limulus longispina, Van der Hoeven, Rech. sur l'Hist. nat. etc. des *Limules*, p. 32, pl. v. (Leyden, 1838).

The type of *L. tridentatus* in the British Museum shows that this species was based upon a young of the Chinese form that Van der Hoeven afterwards described as *L. longispina*.

Distribution. This species has a much more northern range than *T. gigas*, extending to the coast of China and Southern Japan. Southwards it overlaps the area of *T. gigas*. Examples of both species, for instance, have been received by the British Museum from Kudat, in British North

Borneo, where presumably they exist side by side. These specimens, the largest I have seen, measuring about 17 inches long, excluding the postanal spine, which superadds another 19 inches, were presented by Mr. G. W. Johnstone and Capt. S. S. Flower.

Tachypleus Hoeveni, sp. n. (Pl. V. fig. D.)

Limulus moluccanus, Van der Hoeven, Rech. sur l'Hist. nat. etc. des *Limules*, pp. 9–26 & 31, pl. i. figs. 2 & 10, pl. ii. fig. 14 (not pl. ii. fig. 15).

Van der Hoeven's figures of the species he identifies as *L. moluccanus* are most puzzling. The genital operculum of both male and female of his specimens, if we are to trust the artist who figured it, is quite different from those of all the specimens of *Tachypleus* known to me. In the description Van der Hoeven contents himself with saying that the genital operculum has a median fissure in its posterior part (*loc. cit.* p. 15); but the admirable illustrations cited above clearly show that the distal segments of the inner branch of this appendage are disunited in the middle line, with their inner borders sinuous and overlapping. Plate i. fig. 2 of his monograph represents this arrangement in a female which is shown to be adult by the abbreviation of the three posterior spines on the opisthosoma, and plate i. fig. 10 and plate ii. fig. 14 show precisely the same thing in the adult male. The variation is clearly therefore attributable neither to sex nor age, and its occurrence in at least two specimens precludes the likelihood of its being due to abnormal development.

That Van der Hoeven also had a specimen with the operculum resembling that of the species I call *gigas* is indicated by fig. 15, pl. ii., where this appendage is represented in its typical form. Under these circumstances there appears to be no other course than to regard the two types of operculum as belonging to distinct species. In other characters, so far as can be judged, the species appear to be alike.

Distribution. Moluccas.

The distinguishing features of the three species referred to this genus may be tabulated as follows:—

a. Anterior border of carapace of ♂ strongly bi-excised; posterior margin of opisthosoma above the root of the postanal spine armed with three spikes ..... *tridentatus*, Leach.

b. Anterior border of carapace evenly convex in ♂ and ♀; caudal emargination of opisthosoma armed above with a single median spike.

a^1. Distal segments of inner branches of genital operculum disunited and overlapping in ♂ and ♀ ..... *Hoeveni*, sp. n.

b^1. Distal segments of inner branches of genital operculum united in ♂ and ♀ ..... *gigas*, Müller.

Genus Carcinoscorpius, nov.
(Pl. V. fig. B and Pl. VI. figs. 3, 5.)

No spur on apex of fourth segment of last appendage of prosoma. Inner branches of genital operculum extending distally as far as the tips of the outer branches. Postanal spine cylindrical, neither crested above nor grooved below. Claspers of male completely chelate, the fingers long, slender, and similar in form. Movable spines bordering the opisthosoma short in the two sexes, the second and third the longest, the rest either progressively decreasing in length from before backwards in the male, or becoming abruptly shorter in the female.

Type. Species represented by specimens in British Museum identified as *L. rotundicauda*, Latreille, from the Gulf of Siam (*S. S. Flower*, 99. 9. 7. 66).

Carcinoscorpius rotundicauda (Latr.).

Limulus rotundicauda, Latr. in Hist. Nat. Crust. et Ins. iv. p. 98 (1802); id. Sonnini's Buffon, Ins. iv. p. 89 (1802); and of all subsequent authors.

Distribution. This species apparently extends further to the west than *Tachypleus gigas* or *T. tridentatus*. In the British Museum there are examples ticketed "India and Bengal," also others from Malaysia, Pinang, and the Gulf of Siam (*S. S. Flower*); Van der Hoeven's specimens came from the Moluccas, and Moseley has recorded it from Zamboanga in the Philippines.

EXPLANATION OF THE PLATES.

Plate V.

Fig. A. Genital operculum of *Xiphosura polyphemus*, ♂.
Fig. B. Genital operculum of *Carcinoscorpius rotundicauda*, ♀.
Fig. C. Ditto of *Tachypleus gigas*, ♀.
Fig. D. Ditto of *Tachypleus Hoeveni*, sp. n., showing the overlap of the distal segments of the inner branch (after Van der Hoeven).
Fig. E. Second appendage of opisthosoma of *T. tridentatus*, ♂, to illustrate the derivation of the structure of the genital operculum.

Lettering:—I, II, III, segments of the exopodite: 1, 2; 1, 2, 3; and 1, 2, 3, 4, segments of endopodite. The segment numbered 1 here assigned to the endopodite may be part of the second segment of the exopodite separated from it by a secondarily acquired suture.

PLATE VI.

Fig. 1. Third prosomatic appendage of *Tachypleus gigas*, ♂.
Fig. 2. Abnormal clasper of *Tachypleus tridentatus*, ♂, retaining the distal extremity of the immovable finger and illustrating the formation of the hemichelate from the chelate condition.
Fig 3. Third prosomatic appendage of *Carcinoscorpius rotundicauda*.
Fig. 4. Sixth appendage of *Tachypleus gigas*, with spur (*sp.*) on fourth segment.
Fig. 5. Ditto of *Carcinoscorpius rotundicauda*, showing absence of spur.
Fig. 6. Endopodite of branchial appendage of *T. gigas*, showing the sensory organs and absence of spine on penultimate segment.
Fig. 7. Inner edge of last and penultimate segments of endopodite of branchial appendage of *Xiphosura polyphemus*, showing spine (*sp.*).

N.B.—In the Quart. Journ. Micr. Sci. vol. xliv. p. 298 (1901), I drew attention to the presence on the four posterior pairs of prosomatic appendages in *Limulus* of a suture marking the original division of the fourth segment into two, thus bringing the number of leg-segments in Scorpions and *Limulus* into exact agreement. My regret at having overlooked the fact that M. Laurie (Journ. Linn. Soc., Zool. xxv. p. 37, 1894) mentioned the same feature is lessened by the recognition of the value that attaches to the independence of the testimony. The credit of the discovery of this suture belongs apparently to Ranzani (Opusc. Sci. Bologna, ii. p. 279, pl. viii. figs. 2, 7, & 8, 1818), as stated by Van der Hoeven. The latter, however, omits the sutures from his plates.

XLIII.—*On the Geographical Races of the Kinkajou.*

By OLDFIELD THOMAS.

THE Kinkajou (*Potos flavus*, as Mr. Palmer has shown its name to be, better known as *Cercoleptes caudivolvulus*) is spread over Central and Northern South America from Mexico to Ecuador on the west and Guiana on the east; but the specimens from these different regions are not all precisely alike, and a comparison shows that five definable subspecies may be readily distinguished. These may be briefly indicated as follows, more detailed descriptions of the new forms being subjoined:—

1. *Potos flavus aztecus*, subsp. n.

General colour greyer; between "tawny olive" and "clay-colour" of Ridgway. No dorsal streak.
Mexico and Guatemala.

2. *Potos f. megalotus*, Mart.

General colour deeper and stronger, about raw sienna of Ridgway. A dorsal streak usually present.
Costa Rica and Colombia.